A PHENOLOGICAL STUDY OF THE CICADAS (HEMIPTERA: CICADIDAE) IN WESTERN SYDNEY, NEW SOUTH WALES, WITH NOTES ON PLANT ASSOCIATIONS

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Abstract

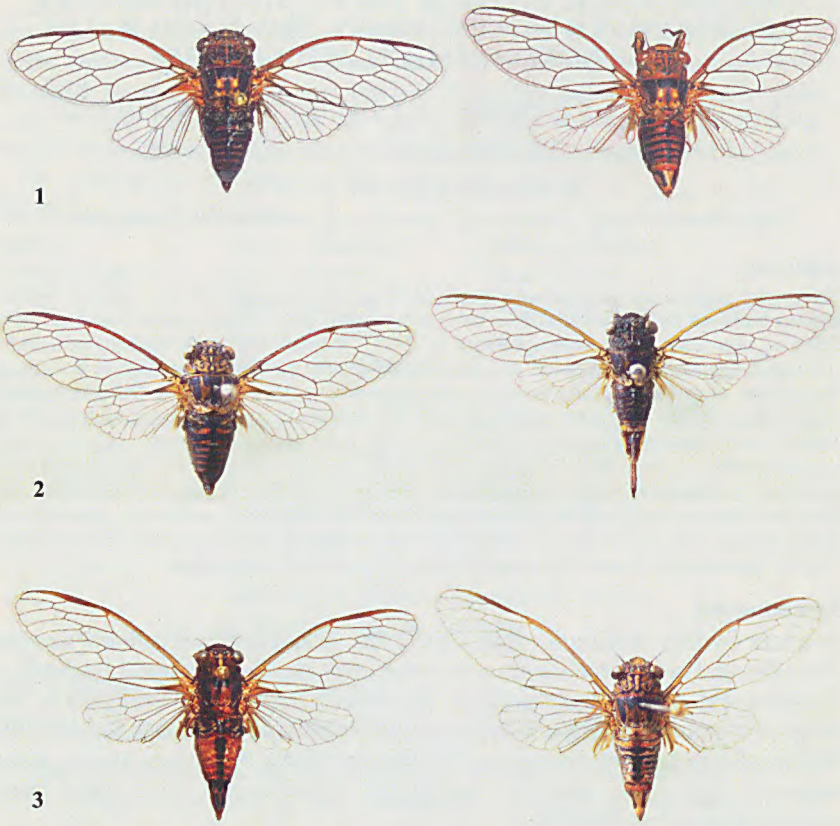
Emergence patterns and temporal occurrence of 29 species of cicadas in three areas of western Sydney bushland are documented from surveys over eight consecutive seasons from September 1996 to May 2004. Sites were inhabited by 11-17 species, with nine undescribed species illustrated. Seasonal fluctuations in emergence patterns were generally dependent on the species and climate, with smaller, early emerging species persisting from October to December, larger species emerging in November and December and additional small species emerging during January and February. The annual numbers of the early emerging species suggest cyclical patterns of three to four years. *Cicadetta celis* Moulds was the first species to appear each year, emerging in September, while *Psaltoda plaga* (Walker) was the last, regularly persisting until May each season. Nearly half the cicada species inhabited *Eucalyptus mollucana*, especially the larger species, and most were associated with other Myrtaceae or *Acacia* spp. (Mimosaceae). Smaller species in the genus *Urabunana* Distant preferred shrubs and grasses.

Introduction

Western Sydney bushland extends from the inland northern suburbs around Hornsby on Hawkesbury sandstone, south over the Cumberland Lowlands to Camden and west of Parramatta to the Nepean River. Only remnants of the original Cumberland Plain woodland remain. Most of the cicada fauna of the Sydney Basin has been documented (Moulds 1990), but less is known about seasonal emergence patterns among the species and their food plant associations and preferences.

This study was undertaken to highlight the cicada biodiversity in western Sydney bushland from three sites that are >5 km inland. The selected sites were chosen because they contained more than ten hectares of relatively undisturbed bushland in different regions of the Sydney Basin that included the different vegetational types associated with the Cumberland Lowlands, Hornsby Plateau and the western extremity of the Wianamatta Shale near the Nepean river. This excluded several Sydney coastal cicada species such as *Arunta perulata* (Guérin-Méneville), *Cicadetta arenaria* (Distant), *C. hackeri* (Distant), *C. hunterorum* (Moulds) and *Pauropsalta aktites* Ewart. Twenty-nine cicada species were recorded and distinct temporal patterns of seasonal emergence were observed.

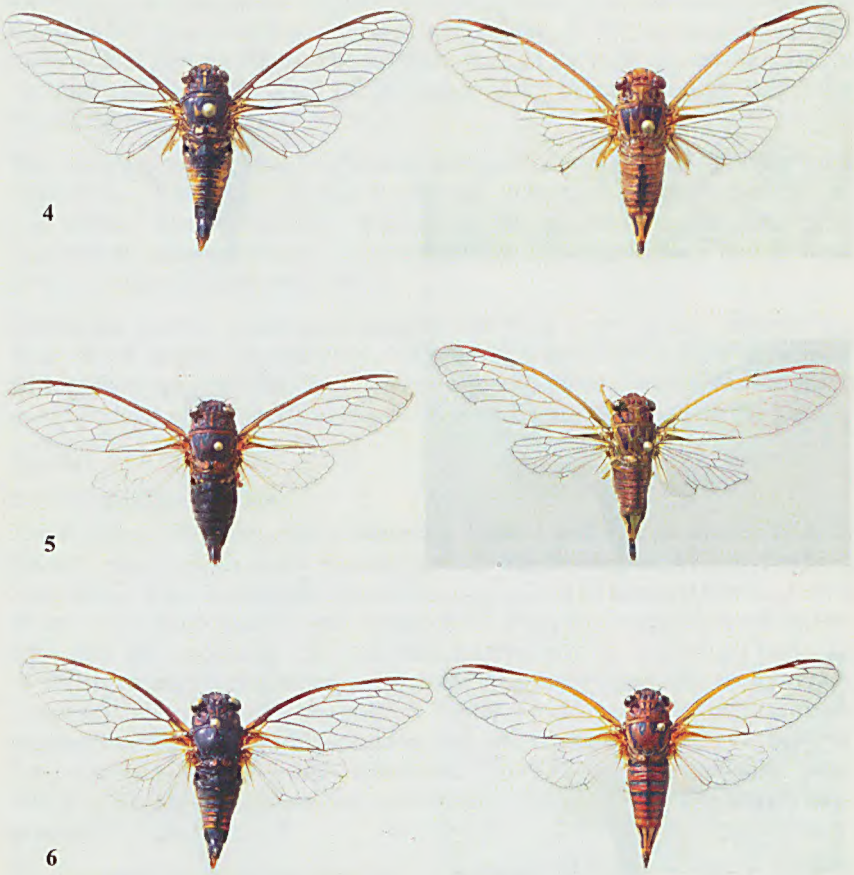
All cicada species dealt with in this study were documented by Moulds (1990) or Moss and Popple (2000), with the exception of nine undescribed species that are reported using the Taxon Numbering System (TNS) of Moss and Popple (2000). These are illustrated in Figs 1-9.



Figs 1-3. Undescribed cicadas taken during the current study (males left, females right). (1) the Ferny Acacia Cicada, *Cicadetta* sp. nr *adelaida* 214; (2) the Montane Grass Buzzer, *Notopsalta* sp. nr *atrata*; (3) the Western Sydney Ambertail, *Cicadetta* sp. nr *celis* 480.

Methods

Three sites within the Sydney basin were selected for this study: (A) Prospect Reservoir Conservation Area (33°49'S, 150°53'E; *ca* 600 ha) in the Cumberland Lowlands, (B) Castlereagh Nature Reserve (33°40'S, 150°45'E; 492 ha) at the western extremity of the Wianamatta shale and (C) Kinka Reserve, Terrey Hills (33°40'S, 151°13'E; 10 ha) in the Hornsby Plateau. Each site was visited at least once per month from September to May the following year, commencing in September 1996 and concluding in May 2004. Specimens were collected by light trapping and by hand. Subsequently, aural and visual observations of cicadas and their exuviae were used to confirm their presence and provide an approximate estimate of abundance.



Figs 4-6. Undescribed cicadas taken during the current study (males left, females right). (4) the Varied Ambertail, *Cicadetta* sp. nr *tristrigata* 486; (5) the Brown Firetail, *Cicadetta* sp. nr *denisoni* 509; (6) the Red Ringer, *Cicadetta* sp. nr *abdominalis* 512.

The vegetation of Prospect Reservoir comprises remnant Cumberland forest woodland on Wianamatta shale soils (Howell and Benson 2000). The dominant trees are grey box (*Eucalyptus moluccana*) and forest red gum (*E. tereticornis*) with occasional stands of broad-leafed red ironbark (*E. fibrosa*). The understorey contains hopbush (*Dodonaea viscosa*), native indigo (*Indigofera australis*) with wattle (*Acacia falcata* and *A. falciformis*) and *Bursaria spinosa*, with exotic African olive (*Olea europaea var. africana*) on the periphery (Howell and Benson 2000). The bushland is periodically burned by fires.

Figs 7-9. Undescribed cicadas taken during the current study (males left, females right). (7) the Southern Bark Squeaker, *Pauropsalta* sp. nr *corticinus* 422; (8) the Sandstone Squeaker, *Pauropsalta* sp. nr *collina* 417; (9) the Southern Red-eyed Squeaker, *Pauropsalta* sp. nr *annulata*.

The native flora of Castlereagh Nature Reserve includes ironbark forest, scribbly gum woodland and swamp woodland (Benson and Howell 1990). The ironbark forest is dominated by *Eucalyptus fibrosa*, *E. siderophloia* and paperbark (*Melaleuca decora*), together with *E. moluccana* in more open areas and a range of understory shrubs to 1 m. The scribbly gum woodland contains *Eucalyptus sclerophylla* and narrow-leaved apple (*Angophora bakeri*), an understorey including *Banksia spinulosa*, *Acacia elongata, Hakea, Grevillea, Leptospermum* and *Melaleuca* species and small clusters of

Allocasuarina glareicola (native she-oak). *Eucalyptus parramattensis, E. siderophloia* and *Melaleuca decora* predominate in the swampy woodland (Howell and Benson 2000). The southern third of the reserve was burnt out in October 1999 and the fires of December 2002 burned through the entire woodland.

The wooded area of Kinka Reserve contains white-trunked scribbly gum (*Eucalyptus haemostoma*), stringybark (*E. oblongata*), brown bloodwood (*Corymbria gummifera*) and isolated stands of *Acacia glareicola*. The understorey is dominated by *Hakea teretifolia*, *Acacia longifolia* and *Banksia serrata* (Benson and Howell 1990).

During the survey, cicada plant associations were observed and recorded for each of the species encountered. Cicadas were considered to be associated with a plant species when individuals were consistently observed inhabiting that particular plant species and exuviae were frequently found on the plant.

Results

Cicada seasonality

The results of the survey are presented in Table 1 and summarized in Table 2. Twenty-nine species were encountered at the three sites (11 at Prospect Reservoir, 17 at Castlereagh Nature Reserve and 14 at Kinka Reserve, Terrey Hills). Only three species were found at all sites; five were common to two sites and the remaining 21 were encountered only at one site (Table 2). Within each site, cicada emergences could be grouped consistently into three temporal clusters: early-season (late September to early November), mid-season (mid November to December) and late-season (January to February). Two species, *Cicadetta celis* Moulds and *Pauropsalta* sp. nr *annulata*, were found to emerge throughout the entire period (September to February), most prominently after rain.

Early-season emergences consisted of a range of small cicada species at Prospect Reservoir, including mainly *Cicadetta tristrigata* (Goding & Froggatt), *C. landsboroughi* (Distant), *C. multifascia* Walker, *C.* sp. nr *celis* and *Pauropsalta* sp. nr *corticinus* (Table 2). The emergence of a number of these smaller species was coincidental, with high levels of multiple species observed in 1991, 1994 and during the study years 1997, 1998 and 2002 (Table 1A). These synchronised levels of abundance did not always comprise the same set of species, but a similar number of 4-6 taxa were recorded in high numbers in each case. Further, the duration of presence for each year showed a similar pattern across these species (Table 1A). *Pauropsalta* sp. nr *corticinus* was the only early species that emerged in every year of the study. The two related species *Cicadetta* sp. nr *celis* and *C. tristrigata* were always present together and both were absent during 2001-2002 (Table 1A). *Cicadetta landsboroughi* and *C. multifascia* showed a similar emergence pattern, both being absent in 1996-1997 and 1999-2000.

Table 1. Abundances of cicada species in three areas of western Sydney, 1996-2004. Populations densities were estimated from direct observation of adults, exuviae and songs. 'x' denotes present in low to moderate numbers, bold '**x**' represents present and abundant. TNS = Taxon Numbering System (Moss and Popple 2000).

A. Prospect Reservoir and environs

Species	TNS	1996-97				1997-98				1998-99				1999-00				2000-01				2001-02				2002-03				2003-04			
		O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M
Ps. plaga	103				XXXX			XXXX				XXXX				XXXX				XXXX				XXX				XXX				XXXX			
A. curvicosta	525				XX			XX				XX				XX				XX				XXX				X				XXXX			
*P.*sp.nr *corticinus*	422				XXX			XX				XX				XX				XX				XX				**XX**				XX			
P. sp. nr *annulata*	434				XXXX			XXX				**XXX**				XX				**XX**				XXX				**XXX**				XXX			
C. sp. nr *celis*	480				XXX			**XXX**				**XXX**				X				X								**XX**				X			
C. celis	481				XXXXX			**XXXX**				**XXXX**				XXX				**XXXX**				XXXX				**XXXX**				XXX			
C. tristrigata	482				XXXX			XXX				**XXX**				XX				X								**XX**				XX			
C. sp. nr *adelaida*	214				X			XX				X								X								X				XXX			
C. labeculata	184				XXX							XXX				XXX				XX								XX				XXXX			
C. landsboroughi	478							**XXX**				**XX**								X								**XX**				XX			
C. multifascia	348							**XX**				**XX**								X				X				XX				XX			

B. Castlereagh Nature Reserve and environs

Species	TNS	1996-97				1997-98				1998-99				1999-00				2000-01				2001-02				2002-03				2003-04			
		O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M	O	N	D	J	F	M
Th. saccata	3							XX				XX				XX										**XXXX**				**XXX**			
M. angularis	59											XX														**XXX**				**XXX**			
H. eydouxii	18							XX				XX								X				X		**XXXX**				XXX			
Ps. plaga	103				XXX			XXXX				XXX						X		XX				XX				**XXXX**				**XXXX**			
Ps. moerens	89				XX			XX				XX								XX								**XX**				XXX			
Ps. harrisii	96																			XX								XX				X			
A. curvicosta	525				XX			XXX				XXX				XX				XXX				XX				XX				**XXXX**			
P. mneme	377				XXXX			XX				XX				XX				XXX				XXX				XXXX				XX			
P. sp. nr *collina*	417				XXX			XXX				XXXX				XX				XXX				XXXX				XXX				**XXXX**			
P. sp. nr *annulata*	434				XXX			XXXX				XXXX				XXX				XX				XXX				XXXX				XXXXX			
P. circumdata	398							XX								XX				XX				X				XX				**XXX**			
C. labeculata	184				XXXX							XXX				X				XX				XXX				XX				XXXXX			
C. spinosa	176				X											XX				XX				XXXX				XX				**XXXX**			
*C.*sp.nr *tristrigata*	486				XX			XX				XX				X				X				**X**				X				X			
N. atrata	281				XX			XXX				XX				XXX				XX				X	XX			X	X			XXX			
U. daemeli	320																				X														
U. verna	327							X				X				XX								**XX**					**XX**			**XX**			

C. Kinka Reserve and environs

Species	TNS	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
		ONDJFM	ONDJFM	ONDJFM	ONDJFM	ONDJFM	ONDJFM	ONDJFM	ONDJFM
Ps. plaga	103	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	XXX	XXXX
Ps. harrisii	96	XXXX	XX	XXXX	XXX	XXXX	XXXX	XX	XXX
Cyc. australasiae	48	XXX	XX	XX	X	XX	XXX	XX	XXX
H. eydouxii	18		XX	XX		X	X	XXXX	XXX
M. angularis	59							X	X
A. curvicosta	525	XX	XXX	XXX	XX	XX	XXXX	X	XXXX
T. tristigma	112		XX			XXX	XXXX	XX	X
C. celis	481	XXX	XXX	XXX	XX	X X	XX XX	XX X	XXXX
C. labeculata	184	XXXX	XX	XXX	X	XX	XXX	XX	XXXX
*C.*sp.nr *tristrigata*	486	X	XX	X	XX	XX	X	X	XXXX
C. sp.nr *denisoni*	509	XX	XX	XX	XXX		XXX	XX	XXX
C. sp.nr *abdominalis*	512	X	X	XX			XX	X	XXXX
N. sp.nr *atrata*	286	XX	XXX	XX	XXX	XX X	X XX	X XX	XX
U. daemeli	320		X						

Mid-season emergences included all the larger species: *Thopha saccata* (Fabricius), *Macrotristria angularis* (Germar), *Henicopsaltria eydouxii* (Guérin-Méneville), *Psaltoda moerens* (Germar), *P. plaga* (Walker), *P. harrisii* (Leach), *Aleeta curvicosta* (Germar), *Cyclochila australasiae* (Donovan) and *Tamasa tristigma* (Germar). The first five of these species all emerged in abundance at the Castlereagh site in the 2002-2003 and 2003-2004 seasons. These were the only observations of significant numbers of large cicadas during the study (Table 2), with the exception of *H. eydouxii* at Terrey Hills in 2000-2001 and 2002-2003 (Table 1C). This species was absent in 1996-1997 and 1999-2000 at both Castlereagh and at Kinka Reserve (Table 1B, C).

Psaltoda plaga, *C. australasiae* and *A. curvicosta* were the only larger species that were present annually. *P. harrisii* emerged annually at Kinka Reserve (Table 1C) but was present only during seasons (2000-2004) at Castlereagh (Table 1B, 2). *T. saccata* and *P. moerens* were both encountered in irregular seasons (Table 1B). *M. angularis* was only detected in two seasons at Kinka Reserve (Table 2) and in three seasons at Castlereagh (Table 1B, 2). Smaller species that emerged during November and December included *Cicadetta spinosa* (Goding & Froggatt) *C. labeculata* (Distant), *C.* sp. nr *adelaida*, *C.* sp. nr *tristrigata*, *C.* sp. nr *abdominalis*, C. sp. nr *denisoni*, *Pauropsalta mneme* (Walker), *P.* sp. nr *collina*, *Notopsalta atrata* (Goding & Froggatt), *N.* sp. nr *atrata* and *Urabunana daemeli* Distant.

Table 2. Summary of the presence / absence of cicada species across three sites in the Greater Sydney area. Eight seasons are represented (1996-2004) and records are illustrated from October-March/May. Site 1 = Prospect Reservoir, Site 2 = Castlereagh Nature Reserve and Site 3 = Kinka Reserve, Terrey Hills. Lighter shading represents a lower number of records over the years, whilst darker shading represents more consistent presence during the study period.

Species	TNS	Site 1						Site 2					
		O	N	D	J	F	M	O	N	D	J	F	M
Thopha saccata	3												
Henicopsaltria eydouxii	18												
Cyclochila australasiae	48												
Macrotristria angularis	59												
Psatloda moerens	89												
Psaltoda harrisii	96												
Psaltoda plaga	103												
Tamasa tristigma	112												
Cicadetta spinosa	176												
Cicadetta labeculata	184												
Cicadetta sp. nr *adelaida*	214												
Notopsalta atrata	281												
Notopsalta sp. nr *atrata*	286												
Urabunana daemeli	320												
Urabunana verna	327												
Cicadetta multifascia	348												
Pauropsalta mneme	377												
Pauropsalta circumdata	398												
Pauropsalta sp. nr *collina*	417												
Pauropsalta sp. nr *corticinus*	422												
Pauropsalta sp. nr *annulata*	434												
Cicadetta landsboroughi	478												
Cicadetta sp. nr *celis*	480												
Cicadetta celis	481												
Cicadetta tristrigata	482												
Cicadetta sp. nr *tristrigata*	486												
Cicadetta sp. nr *denisoni*	509												
Cicadetta sp. nr *abdominalis*	512												
Aleeta curvicosta	525												

Table 2 (cont.). Summary of the presence / absence of cicada species across three sites in the Greater Sydney area. Eight seasons are represented (1996-2004) and records are illustrated from October-March/May. Site 1 = Prospect Reservoir, Site 2 = Castlereagh Nature Reserve and Site 3 = Kinka Reserve, Terrey Hills. Lighter shading represents a lower number of records over the years, whilst darker shading represents more consistent presence during the study period.

Species	TNS	Site 3 O N D J F M
Thopha saccata	3	
Henicopsaltria eydouxii	18	
Cyclochila australasiae	48	
Macrotristria angularis	59	
Psatloda moerens	89	
Psaltoda harrisii	96	
Psaltoda plaga	103	
Tamasa tristigma	112	
Cicadetta spinosa	176	
Cicadetta labeculata	184	
Cicadetta sp. nr *adelaida*	214	
Notopsalta atrata	281	
Notopsalta sp. nr *atrata*	286	
Urabunana daemeli	320	
Urabunana verna	327	
Cicadetta multifascia	348	
Pauropsalta mneme	377	
Pauropsalta circumdata	398	
Pauropsalta sp. nr *collina*	417	
Pauropsalta sp. nr *corticinus*	422	
Pauropsalta sp. nr *annulata*	434	
Cicadetta landsboroughi	478	
Cicadetta sp. nr *celis*	480	
Cicadetta celis	481	
Cicadetta tristrigata	482	
Cicadetta sp. nr *tristrigata*	486	
Cicadetta sp. nr *denisoni*	509	
Cicadetta sp. nr *abdominalis*	512	
Aleeta curvicosta	525	

All of the mid-season *Cicadetta* Amyot species were present for different durations each season in relation to unstable weather and emergence times were generally erratic. In contrast, emergence of *Pauropsalta* Goding & Froggatt species was more predictable and both *P. mneme* and *P.* sp. nr *collina* were present annually (Table 1B). The two *Notopsalta* Dugdale species also emerged in all years, sometimes emerging twice in one season (Table 2). Second emergences were also observed in *P.* sp. nr *corticinus* in 2002-2003 (Table 1A) and *Cicadetta celis* in 2000-2001 and 2001-2002 (Table 1C). *Urabunana daemeli* was uncommon at both Kinka Reserve and Castlereagh, being only recorded once in 1997-1998 and 2000-2001 respectively (Table 1B, C). Due to its inconspicuous nature, it is possible that this species was overlooked during visits to these sites.

Two late-season species, *Pauropsalta circumdata* (Walker) and *Urabunana verna* Distant, usually emerged after any rainfall in mid January and persisted into February if temperatures were moderate.

Cicada plant associations

The plant associations of the cicadas encountered at the three sites are summarised in Table 3. Cicadas were predominantly found to be associated with eucalypts and many inhabited the dominant trees at each site. Fifteen species occurred in *Eucalyptus mollucana*, which is a particularly prominent tree species both at Prospect Reservoir and Castlereagh Nature Reserve. All eucalypt-dwelling cicadas were found to be associated with several other myrtaceous species, with the exception of *Pauropsalta mneme*, *P. circumdata*, *Cicadetta* sp. nr *denisoni* and *C. spinosa* (Goding & Froggatt), which were only found on *Eucalyptus racemosa*, *E. mollucana*, *E. saligna* and *E. fibrosa* respectively (Table 3; Emery and Emery 2002).

Despite most species having a strong affinity with myrtaceous plants, a small number of species were also found on quite unrelated vegetation. For example, *Cicadetta* sp. nr *celis* was common on *Eucalyptus mollucana*, *E. fibrosa* and *Melaleuca decora*; however, at Prospect Reservoir adults were consistently found occurring in a grove of introduced *Olea europaea*. *Cicadetta* sp. nr *abdominalis* occurred on the eucalypt *Corymbia gummifera*, but was just as prominent on *Hakea* sp. and *Grevillia* sp. at Kinka Reserve. *Cicadetta multifascia*, *C. landsboroughi* and *Notopsalta atrata* all occurred on myrtaceous plants, but all were also commonly encountered in unidentified grasses and their exuviae were often found in grass. *Psaltoda plaga* inhabited *Melaleuca decora*, but was also common in *Casuarina glauca* at Prospect Reservoir and at Castlereagh it was encountered mostly on *Acacia glareicola*.

Acacia spp. (Mimosaceae) were not found to be dominant at any of the sites, but were present in small clumps with a small number of associated cicadas. One species, *Tamasa tristigma* (Germar), was restricted to *Acacia glareicola*

Table 3. Cicada species and their plant associations based on observations at Prospect Reservoir, Castlereagh Nature Reserve and Kinka Reserve in Sydney, NSW, from 1996-2004.

Cicada species	Plant species associations
Thopha saccata	*Eucalyptus mollucana, E. racemosa, Angophora bakeri*
Cyclochila australasiae	*E. globoidea*
Henicopsaltria eydouxii	*E. mollucana, E. racemosa, E. haemastoma, A. bakeri*
Psaltoda moerens	*E. mollucana, E. racemosa, A. bakeri*
Psaltoda plaga	*Casuarina glauca, M. decora, Acacia glareicola*
Psaltoda harrisii	*E. mollucana, E. racemosa, A. bakeri*
Macrotristria angularis	*E. mollucana, E. racemosa, A. bakeri*
Tamasa tristigma	*Ac. glareicola*
Aleeta curvicosta	*Melaleuca decora*
Cicadetta spinosa	*E. fibrosa*
Cicadetta labeculata	*Ac. longifolia, Ac. elongata, E. racemosa*
Cicadetta celis	*M. decora, Leptospermum* sp.
Cicadetta sp. nr *tristrigata*	*E. mollucana, E. racemosa, A. bakeri*
Cicadetta sp. nr *celis*	*E. mollucana, E. fibrosa, M. decora, Olea europaea*
Cicadetta sp. nr *abdominalis*	*Corymbia gummifera, Hakea* sp., *Grevillea* sp.
Cicadetta sp. nr *denisoni*	*E. saligna*
Cicadetta sp. nr *adelaida*	*Ac. parramattensis, Ac. falciformis, Ac. falcata*
Cicadetta tristrigata	*E. mollucana, M. decora*
Cicadetta landsboroughi	*E. mollucana, M. decora,* grasses
Cicadetta multifascia	*E. mollucana, M. decora, Bursaria spinosa,* grasses
Notopsalta sp. nr *atrata*	*E. globoidea, E. haemastoma*
Notopsalta atrata	*E. mollucana, E. racemosa, A. bakeri,* grasses
Pauropsalta mneme	*E. racemosa*
Pauropsalta circumdata	*E. mollucana*
Pauropsalta sp. nr *corticinus*	*E. mollucana, M. decora*
Pauropsalta sp. nr *collina*	*E. mollucana, E. racemosa, A. bakeri*
Pauropsalta sp. nr *annulata*	*E. mollucana, E. fibrosa*
Urabunana verna	grasses, *Pimelia* sp.
Urabunana daemeli	*Leptospermum* sp., small *Hakea* sp.

at Kinka Reserve. Two *Cicadetta* species, *C. labeculata* and *C.* sp. nr *adelaida*, were both encountered almost exclusively on acacias. The latter species was commonly found on *Acacia parramattensis*, as well as on *A. falcata* and *A. falciformis*. *Cicadetta labeculata* occurred on *Acacia elongata* and *A. longifolia* and was often found on *Eucalyptus racemosa*.

Cicadetta celis was one of the few species that was found to inhabit *Leptospermum* (Myrtaceae) on a regular basis. The affinity with this food plant was also shared by the rather scarce *Urabunana daemeli* at both Castlereagh and Kinka Reserve. The distantly related *U. verna* was restricted to grass and small shrubs, such as *Pimelia* sp. (Thymeliaceae), at Castlereagh Nature Reserve.

Discussion

This survey, over eight seasons, highlights the sequential seasonal emergence of Sydney's cicada fauna as well as the high and similar diversity of cicada species in the three sites of Sydney bushland examined.

The numbers of species found were similar to numbers found in several other areas of NSW bushland around Blackheath in the Blue Mountains (10 species) and on the South and Central NSW Coasts (15 species) (authors' unpublished data). Since cicadas show strong preferences for host plants, the larger number of species found at Castlereagh Nature Reserve may be a consequence of the greater diversity of floral communities found at this site.

The smaller cicada species emerged more regularly each season than larger species although their numbers were more variable. An examination of the population numbers for *Cicadetta tristrigata, C. landsboroughi, C. multifascia* and *C.* sp. nr *celis* suggested a generational interval of 3-4 years. Several of the larger species were found only in one or two years over the entire 8 years surveyed. Since cicadas tend to emerge in batches in a given season (Moulds 1990), both these observations are explained by the time spent underground before emergence. Most cicada species have multiple-year life cycles, with larger species thought to remain underground for periods ranging from 2-8 years (de Boer and Duffels 1996) and some smaller species completing annual cycles (Moulds 1990). Therefore, the lower numbers of larger species observed during the survey may be due to chance, with an absence of emerging broods. Low numbers recorded for some small cicadas such as *Urabunana daemeli* may be due to adults having gone unnoticed.

The survey revealed a consistent sequential emergence pattern of species throughout the Sydney season from September to January, with adults of some species persisting until March or even May. Many of the smaller species had completed their life-cycle prior to the emergence of the larger species in mid to late November. The regulation of these sequential emergences is not clear but similar patterns have been previously reported in a four-year survey of cicadas in the New England region of NSW (Coombs 1996) and from a census of exuviae around Caloundra, north of Brisbane (Ewart 2001).

Several interactive factors may stimulate cicada emergences, including ambient and soil temperature, sap flow in food plants and rainfall that may assist final tunneling of the exit hole. The influence of rain and temperature is

evident from the temporal and consistent emergence patterns of the world's cicada species as the inter-tropical convergence zone (ITCZ) oscillates through the tropical regions. The unexpected emergence, 3-4 weeks early, of large and medium-sized cicadas in 2002 during a drought could indicate that ambient temperature provided a direct signal or triggered an earlier seasonal increase of sap flow in food plants. The emergence of *Magicicada* Linnaeus nymphs in the USA appears to occur after soil (and resident cicada) temperatures exceed 64°F and, because emergence is temperature-dependent, periodical cicadas tend to emerge earlier in southern areas and at lower elevations (Williams and Simon 1995).

Of particular interest is the pronounced emergence of all large cicada species in 2003, for the second season in succession. The previous marked emergence around Sydney was 1994 (authors' records), suggesting either a generational interval of perhaps 8 years, or particularly conducive conditions for the development of egg batches from previous seasons. These emergence patterns emphasize the need for observations over extended time scales.

Nine undescribed species were recorded consistently throughout the period of study. Only one species (*Cicadetta* sp. nr *tristrigata*) appears to be restricted to the Sydney Basin, while the remainder have been collected from adjacent coastal and mountain regions as well as at other locations in eastern Australia. *Cicadetta* sp. nr *celis* and *C.* sp. nr *tristrigata* are contained in the *C. tristrigata* complex, while *C.* sp. nr *denisoni* and *C.* sp. nr *abdominalis* belong in the *C. denisoni* Distant and *C. abdominalis* Distant complexes respectively (Moulds 1990). Their songs are different from those of other members within the complexes, highlighting the taxonomic complexity of Cicadettini genera.

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